

RAND

*New Foundations for Growth:
The U.S. Innovation System
Today and Tomorrow*

An Executive Summary

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PREFACE

This document culminates a year-long process of soliciting input and examining options for government action to support the national innovation system. The project was conducted by the Science and Technology Policy Institute at RAND for the National Science and Technology Council (NSTC) under the direction of Dr. Duncan Moore of the White House Office of Science and Technology Policy. NSTC co-Chairs, Morton Downey (Department of Transportation) and Gary Bachula (Department of Commerce,) provided direction for the interagency committee. A steering committee with representatives from business groups such as the Council on Competitiveness, the Industrial Research Institute, state groups such as the State Science and Technology Institute, and academic groups such as the Woodrow Wilson Institute advised the effort.

The process included a call for papers that went out to hundreds of businesses, business organizations and associations, and laboratories to seek ideas for how to either remove obstacles to innovation or improve government policy in support of innovation. The goal was to identify those policies that did not require new government budget authority and which could be accomplished in the near-term (1-3 years.)

The initial set of papers, published on a web site established for the effort, were synthesized into a set of questions for the Summit on Innovation held at the George Washington University in December 1999. This was followed by a June 1999 workshop exploring various scenarios as they might affect the national innovation system under diverse conditions. A synthesis of the findings from all these efforts, as well as a review of relevant literature, resulted in the recommendations contained in this document.

The project team received direct guidance from Lori Perine, Deputy Associate Director for Technology at the White House Office of Science and Technology Policy. Project interns Irene Brahmakulam and Lori Shapiro provided invaluable assistance throughout the course of the project.

Created by Congress in 1991 as the Critical Technologies Institute, the Science and Technology Policy Institute was renamed in 1998. The Institute is a federally funded research and development center sponsored by the National Science Foundation and managed by RAND. The Institute's mission is to help improve public policy by conducting objective, independent research and analysis on policy issues that involve science and technology. To this end, the Institute

- supports the Office of Science and Technology Policy and other Executive Branch agencies, offices, and councils
- helps science and technology decisionmakers understand the likely consequences of their decisions and choose among alternative policies

- improves understanding in both the public and private sectors of the ways in which science and technology can better serve national objectives.

S&T Policy Institute research focuses on problems of science and technology policy that involve multiple agencies. In carrying out its mission, the Institute consults broadly with representatives from private industry, institutions of higher education, and other nonprofit institutions.

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NEW FOUNDATIONS FOR GROWTH:

The U.S. Innovation System Today and Tomorrow

Executive Summary

THE NATIONAL INNOVATION SYSTEM

The transformation of the U.S. economy over the past twenty years has made it clear that innovations based on scientific and technological advances have become a major contributor to our national well-being. The system that supports this process has emerged as one of our most important national assets, as important a source for growth today and in the future as have been in the past the nation's natural resource endowment, the talents and dedication of its workforce, and the accumulated stock of its capital goods.

Our understanding of innovative activity in the U.S. has also changed and grown more sophisticated. Discussion of innovation has shifted from a focus on products (identifying critical technologies, for example) to processes, from individual outputs to the mechanisms for producing those outputs. During this transition, the realization has grown that this system constitutes a dense and complex network of interconnected parts. The major actors in this system --the private sector, government agencies and labs, universities, the non-profit research sector-- relate to each other in complex ways neither easy to describe nor trace through the system.

This interconnected network constitutes what has come to be called a national innovation system.¹ Given the fundamental importance of this system to public welfare and the continuing importance of government as both a participant and a provider of crucial elements of support, it is appropriate to understand what kinds of government actions (or for that matter, inactions) would contribute most to the continued development and health of the system or, conversely, detract from that development and health the least.

To address this set of issues, the National Science and Technology Council convened a series of events to weigh the insights and opinions of participants and observers from every part of the innovation system -- businesses, industry groups, labor, federal and state government, and

¹ The term dates at least from the early 1990s. See, for example, *National Innovation Systems: A Comparative Analysis*, ed. Richard R Nelson, Oxford U Press, New York, 1993.

universities. This executive summary and the longer report it draws from² are based on discussions begun with the latest National Critical Technologies Review, the study "New Forces at Work", and continued through the National Science and Technology Council's Summit on Innovation and a culminating Innovation Scenarios Workshop held under the same auspices.³

This executive summary presents the major themes emerging from these deliberations as elaborated on in the larger report. The discussion seeks to emphasize issues and proposals that have received support across the political spectrum in an attempt to draw from the discussions a first step toward common ground on current and emerging needs. This task is a difficult one -- given the diversity of topics covered, the many interests involved, and the multiplicity of views expressed--and not without risk. While the authors have attempted to provide an accurate report of discussions, inevitably there is much room for interpretation. The reader should not, therefore, read what follows as the findings from detailed analysis but rather as an effort of reportage providing a framework for a series of wider discussions.⁴

The first section below outlines what scholars and our interlocutors say about the nature and health of the national innovation system--its dimensions, current strengths, and weaknesses in both the private and public sectors. The next lays out a synopsis of policy guidelines and proposals for maintaining the system's health as derived from the discussion among participants. In this case, maintenance includes not only ameliorating present problems, but also anticipating future ones and, what is more, ensuring an ability to exploit opportunities that may present themselves. The final section calls attention to those proposals that would benefit from early policy attention and action by the next administration.

STRENGTHS AND STRESSES IN THE NATIONAL INNOVATION SYSTEM

During the Innovation Summit, the participants were asked in the course of topical working sessions to consider a series of questions about the current state of the national innovation system:

- what seems to be working well?
- what refinements or reforms to existing policy institutions or programs may be needed?

² *New Foundations for Growth: The U.S. Innovation System Today and Tomorrow*, Steven W. Popper and Caroline S. Wagner, RAND, (forthcoming.)

³ Held respectively on November 30 – December 1, 1999 at George Washington University and June 21-22 at RAND Washington. Please see Appendix for fuller description.

⁴ The authors have attempted to provide as objective a synthesis as possible, but in the final analysis any work of this type must to an unavoidable degree also be a product of the world view its authors possess. Therefore, while every attempt has been made to place the present discussion on an objective footing, the views expressed must be understood to represent those of its authors and not in any way necessarily those of the Office of Science and Technology Policy, the National Science Foundation, the National Science and Technology Council, or any other public or private institution.

- what new institutions or programs are needed?
- what new research or study is needed on the operation of the national innovation system? On effects of government policies and actions? And on new methodologies of assessment and decisionmaking?

In the course of these discussions, participants also suggested responses to the mirror image of these questions: What areas are not proper for public involvement? What programs or institutions have outlived their usefulness? The passages below attempt to capture the main themes that emerged from the discussion these questions prompted.

The Private Sector

U.S. business has shown a remarkable ability to innovate and to capitalize on innovation in the marketplace. The elements of the national innovation system largely centered in the private sector possess notable strengths, among them:

- Industry responds rapidly to new technologies and new ideas in the marketplace.
- Private firms are flexible and adaptive, certainly more so than the governmental or academic sectors, and can accommodate change more easily.
- The efficiency with which industry approaches the product life cycle is also a strength of the business sector.
- Entry, exit, and the factors involved in ramping up a new product or business or allowing unprofitable activities to wind down is a process facilitated well by industry.
- Capital flows easily and is less bounded than in other sectors, ensuring that promising new areas have funding.
- The overall mobility of factors, the willingness to move manufacturing or research to more productive locations, the willingness to license technology, and the ability to retrain workers, are all strengths within the system.

To point out the success of this machinery for developing and implementing innovation is not to suggest that the private sector can address all concerns equally well. We are speaking not necessarily of failures or shortcomings but rather of weaknesses that may inherently exist, often as a concomitant of successfully pursuing the course the private sector demands:

- Managing under uncertainty becomes increasingly challenging as competition widens and the pace of change increases.
- Balancing needs of customers with social welfare is not necessarily consistent with the fiduciary responsibilities of management.

- Relatedly, long-term systemic consequences of individual actions are beyond the power of firms to foresee or to counteract.
- The "down side" of the private sector's skill at marshaling resources for investment in "hot" areas is that other opportunities that may have longer term or less appropriable pay-offs get insufficient attention.
- And, of course, externalities and market failures of various sorts are by definition beyond the purview of private enterprise.

The Public Sector

Many of the holes left by the private sector in the fabric of innovative activity are not owing to failure of action or short-sightedness. Rather, they require perspectives and actions that are not rightly viewed as the responsibility of firms. There is an economic argument for the public sector to play an appropriate part. The resulting roles include direct and indirect assistance to the processes of innovation, as well as support for the infrastructure that enables economic activity.

Direct support actions include:

- Funding for basic research and development ;
- Protecting intellectual property, copyrights, and trademarks and the legal system of judges and courts that help defend these rights;
- Aiding efforts to set technical standards;
- Agricultural and manufacturing extension services, particularly those helping small business;
- Procurement decisions by agencies;
- General programs lending more tailored assistance through programs like the Small Business Innovation Research program or the Advanced Technology Program.

More indirect efforts include:

- Protecting the integrity of the overall financial infrastructure;
- Fiscal policies such as taxation and the granting of tax credits;
- Improving the educational system;

- Developing transportation and information infrastructures that facilitate commerce;
- Assisting trade through export financing, protection against unfair trading practices by other countries, identification of trading opportunities, and efforts to open markets.

Government has had a substantial effect on the success of the national innovation system by operating through these mechanisms. Changes in policy have led to noticeable changes in the system's operations, often in response to private sector requests. In addition, public sector institutions have the ability to articulate a public agenda and then act as catalyst. Government's role as a convenor of different interests helps to build bridges across disciplines and between upstream and downstream activities. One of the key features of the innovative process is network building. It is through close interaction with competitors, suppliers, and customers that dynamic markets are created. Relationships among institutions are becoming an important policy issue for government agencies. When such networks are weak, public institutions may be used to put in place a process enhancing the connections between firms and the other organizations that contribute to the innovative process.

Government is also able to mobilize capital in directions that are difficult or of little interest to industry. By focusing on areas that need particular help, or where basic research is not being conducted, government is able to leverage investment and create new knowledge that industry can use. Government is also a large and influential purchaser of goods and thus has influence on how products are developed, used, and marketed.

Finally, government also enforces rules that help to keep the system healthy. Moreover, it is left to public sector institutions to provide ways and means for dealing with issues arising from private sector actions that are not adequately addressed by markets, such as environmental clean-up or consumer protection. When viewed as part of the larger system within which innovation takes place, these rule-setting roles and efforts to ensure consumer safety are key to the overall facility with which innovation takes place.

POLICY IN SUPPORT OF A HEALTHY NATIONAL INNOVATION SYSTEM

As befits an area of policy touching on a system of such complexity, the recommendations ensuing from the various contributions solicited by the NSTC present widely different characteristics. These recommendations as a set are spanned by several axes:

- Degree of federal responsibility (e.g., there is a large role in Research & Experimentation tax credit policy, more of a shared effort in education;)
- Strength of the current consensus on fundamental principles or policy initiatives;
- Time course for action (some issues could profit from immediate attention while others could profit from a more measured tempo for consideration;)

- Functional focus of policy recommendations: Some are suggestions for removing government policy obstacles that may exist within the system, others are explorations of possible new institutions or functions, while a third group call for greater understanding and research to properly inform both the need for policy and policies themselves.

While all of these are reasonable organizing principles, the presentation of recommendations below is organized to emphasize support to U.S. innovative activity when viewed as an integrated system. We wish to avoid dissecting the system in a way that loses sight of the dynamics that define it as a whole. Further, in as much as the intent is not to lay out a narrow policy course to be followed by individual government agencies or other public policy institutions, by speaking more of “verbs” than “nouns” the desire is to increase generality of the discussion of policy directions. Individual agencies or policy makers may then use these policy directions to craft more specific actions or decisions. Therefore, the recommendations are arranged to suggest means for **ensuring inputs** to the system, **maintaining the environment** for private and public innovative activity – and improving it, **supporting communications** between elements of the system, and finally, **better understanding the dynamics** which drive the national innovation system and creating appropriate policy in support of them. The final report this summary draws from contains discussion, findings, and recommendations from the various NSTC-sponsored activities. What follows is a selection of highlights from the longer list.

A. Ensuring Adequate Inputs

1. Education and Training

Recommendation: a) Improve the quality of K-12 education in general and raise the level of math and science education in particular.

- b) Expand options for access to science and technology education among groups currently under-represented in the workforce of those fields.*
- c) Increase opportunities for re-training in science and technology for the current workforce.*
- d) Take measures to determine that resources and incentives are in place to ensure the output of a sufficient supply of technically trained professionals from institutions of higher education.*

Education is seen as the key input to an increasingly knowledge-based economy and society. It is also the critical connection between the national innovation system and the larger society. Though the federal government shares a role with other state and local authorities in education, this was held to be an area requiring immediate and concentrated attention.

2. Portfolio of public research

Recommendation: a) Ensure adequate levels of public funding for fundamental science and engineering research.

- b) Funding decisions should be made in a more informed process for assessing priorities and providing balance across fields in a manner commensurate with the complexity of the national innovation system.*

The second area of widest concurrence was on the need for ensuring adequate public support to basic research and to avoid the mistake of thinking the private sector is willing, capable, or appropriate for taking over this role entirely. The concern is that the long lag times between basic research and practical result can cloud the perception of how much our present prosperity and prowess in innovation is based upon research done many years ago.

3. General Policy to Enhance Resources: Research & Experimentation Tax Credits

Recommendation: a) Consider whether making the R&E tax credit permanent would be beneficial to the national innovation system and the larger economy.

The mechanisms for private sector financing of innovative activity is one of the present sources of U.S. strength. Many have viewed the research & experimentation tax credit as an important contribution to this strength. It is attractive to the extent it provides a targeted effect through general application of an indirect policy. Several bills have been introduced in Congress to make the R&E tax credit permanent. Because of both its potential importance as well as the need to tune its focus, effect, and better understand potential outcomes, the question of how best or whether to extend this lever should be among the issues addressed in the near term.

4. Targeted Policies to Enhance Resources

Recommendation: a) Evaluate the development of mechanisms to encourage investment in emerging technology sectors that currently receive limited venture capital funding and how such sectors and points of advantageous entry might be determined.

Consensus over policy in support of the national innovation system tends to shrink as proposals become more targeted. Even so, there was a general sense that some sectors of potential importance to national well-being are not receiving adequate attention. Ventures in information and biotechnologies have greater access to funding than do those, for example, in materials sciences. There do exist programs such as the Advanced Technology Program (ATP) as well as other means to lend assistance to innovation in such sectors. It remains to determine what areas require more attention, how such attention should be applied, and how to assess the net public gain from such efforts.

B. Maintaining a Favorable Environment

1. Intellectual Property Protection

Recommendation: a) Consider what measures may be required to ensure that patent review processes maintain currency with new technology developments.

b) Assess the effects of recent policy changes (such as the Bayh-Dole and Stevenson-Wydler Acts) on the flows and balance of government-funded research and their effects on private sector activities.

In an economy where the national innovation system is a key player and knowledge is the chief currency of that system, the ability to define and defend intellectual property rights is crucial. This is an area fraught with complexities as well as considerable divergence of

sometimes passionately expressed views. It is clear that there would be considerable benefit to the nation in coming to an understanding of what demands are being placed on the intellectual property protection system, how those demands have and are likely to shift, and how well the system is and is likely to be able to meet those demands.

2. Standards

Recommendation: a) Begin a systematic review of the process for setting technical standards considering both the potential importance and limitations of government involvement.

b) Consider the role and process of standard setting as an aspect of U.S. trade policy.

Technical standards affect rates of technological development in many industries. Failure to agree on domestic standards has been pointed to as a principal reason why non-U.S. firms were able to capture both technological and market leads in cellular telephony. Yet, simple policies will not suffice: setting standards too early may foreclose promising lines of development and sources of potential advantage. The U.S. standards infrastructure is characterized uniquely by a loosely coordinated system of federal, state and local governments, voluntary standards associations, trade and professional organizations, for-profit entities, and industry semi-permanent and ad-hoc groups. The government has a significant role to play in seeking to make certain that cross-national efforts at harmonization of standards does not come at the expense of U.S. interests. Government also has a potentially crucial indirect role to play as a convenor and provider of auspices for fostering earlier discussion of standards among and within industry groups.

3. Infrastructure

Recommendation: a) Assess national needs for new measurement and testing systems that would create a benefit across industries.

b) Examine federal investment priorities to ensure public investments in infratechnologies are sufficient to sustain the growth and development of the national innovation system in desired directions.

The national innovation system requires an appropriate infrastructure, including not only the physical capital represented by research apparatus and laboratories but also "infratechnologies" that support R&D across a spectrum of technology sectors. Analysts have identified infratechnologies as: (1) basic scientific and engineering data (such as specific data on chemicals used in engineering processes) needed to conduct R&D and control production, (2) measurement and test methods used in R&D, process monitoring and control, and performance verification; and (3) standard practices and techniques, such as process control models, that allow efficient design and use of industrial technologies. This suggests at the least an assessment role for government. Private companies typically under-invest in the development of improved infratechnologies because they lack the needed capital and technical staff and because of the difficulty in retaining all the benefits from such efforts which almost invariably serve a wider public – including competitors.

4. Partnerships

Recommendation: a) Evaluate the importance of various kinds of partnerships, as well as public-private consortia, in pursuit of innovative activity, determine when the public good would best be served by their coming into being, and consider how these may be fostered.

b) Define clearly where the boundaries for legal cooperation and research lie among firms in the private sector as well as between firms and the government.

c) Consider what policy guidelines would be needed for informing the construction and operation of partnerships with a public component.

There exist many informal partnerships within the national innovation system, a principal one being that between the federal government and private industry in funding new knowledge. Formally specified partnerships may be research collaborations between two firms, a firm and a public sector institution such as a laboratory or a university, or may be complex consortia consisting of many different types of participant. The phenomenon of increased partnering raises many questions related both to the net public benefit and to determining when such partnerships are beneficial and how they may be fostered. Partnering of various types appears to be one of the emerging characteristics of innovative activity heading into the 21st century. It needs to be better understood as a possible vehicle for public policy.

C. Improving Communications

1. Coordination within the Public Sector

Recommendation: a) Raise the awareness of federal agencies to issues affecting the national innovation system and their own roles within that system.

b) Seek to define and identify best practice across federal agencies and promote learning and transfer of such practices to other settings.

c) Seek opportunities to create or use existing forums and venues to foster discussion among federal agencies, between federal agencies and their state and local counterparts, and between government, industry, and academia on issues of common interest affecting the national innovation system.

Although it is convenient to speak of a federal R&D portfolio, this is largely a de facto construct resulting from the aggregation of funding decisions made at agency and program levels. The parts of the public sector dealing with issues related to or arising from the activities and outputs of the national innovation system themselves constitute a complex network of interactions neither easy to describe nor predictable in ultimate effect. This includes not only federal agencies but offices and bureaus at the state and local levels as well. Ultimately, the question is whether the present system as it currently stands is sufficient to ensure that the public good will be directly served and will achieve the best allocation of resources toward meeting national goals, or whether some revision is required. What is worth pondering is how we might be better able to achieve communication and purposeful articulation of observations, policies, and actions across the spectrum of public sector actors. There certainly is room for diffusing best practices in dealing with S&T and innovation-related issues from agencies that have effective systems in place to those which might benefit from emulation.

2. Industry and Government

Recommendation: a) Seek ways to recognize explicitly the de facto partnership and mutuality of interest between public and private sector institutions in support of the national innovation system and to enhance the complementarity of activities.

There are an increasing number of points of tangency between the activities of the private sector and those of the public sector. There is general agreement on the respective relative strengths that each uniquely possess. It is growing more common to hear individuals and organizations operating in each sector suggesting that the answer to some of their particular problems lie in cooperation and some degree of mutual cognizance of the other's actions. The purpose of this recommendation is to make explicit what appears to be both a fundamental change in shared outlook and a potential for new types of public/private interaction. This is not a call for merging private and public interests and lines of responsibility. Quite the contrary, the suggestion is that government agencies should seek means for framing and mounting initiatives with full consideration of the private sector as a source of insight and of implementation. The goal is to identify those areas where the limited means available to those seeking action toward a common end may be made complementary and so hasten the realization of mutually satisfactory outcomes.

Clearly, this is only the broadest description of what perhaps should not even be termed a policy direction. Yet, it reflects a strong current for change that should be recognized and borne in mind when considering more specific measures.

3. Improving Understanding by the General Public

Recommendation: a) Seek means to raise the public awareness of the importance for issues of general concern of innovative activity and what is required through public actions to support that activity.

b) Raise the prominence of formal awards for leadership in the field of technology development.

Inadequate effort has been made in making clear to the general public the connection between many of the benefits they seek or have come to enjoy and the outputs from activities constituting the national innovation system. Yet, not only is the connection an important one, it is also subtle. But if it cannot easily be made simple, it may perhaps be made more accessible. This is not an area calling for bold initiatives as much as for small steps and, most especially, of becoming more attuned to possibilities that may present themselves. For example, it is worth considering how awards and prizes for technology leadership could be raised in prominence as a means for signaling the importance and nature of the activities of the national innovation system.

D. Maintaining Dynamism

1. Data Issues: Toward Better Understanding of the National Innovation System

Recommendation: a) Improve timely access to available government agency data on innovative activity; harmonize existing government data bases.

b) Increase incentives for agencies to collect data on innovation and technology use and transfer through special surveys and by expanding routine collections.

c) Develop new measures and data categories to improve understanding of the innovation system and the interplay between public and private actions.

There is much about innovative activity, innovation policy, and the intersection of the two that is not well understood. We need to provide ourselves with better data, make better use of the data we possess, and make data access easier. This certainly would have consequences for crafting government policies, either direct or indirect, in such a way as to have the most positive effect on this system. Responsibility for collecting and collating such data need not fall solely on individual agencies, both federal and local. Much could be gained by better harmonization among collected data sets linked to one another. Moreover, it might be possible to consider public-private partnerships to produce information useful to both corporate managers and public policy makers at less cost and effort and with less burden on respondents.

2. Anticipating Needs and Consequences:

Recommendation: a) Explore new means to assist in formulating policies that will be adaptive and robust to a variety of possible outcomes rather than static and restrictive.

b) Explore new means to enhance foresight and forward thinking about developments in the national innovation system and the implications of its actions for the society and economy.

The standard tools of analysis we have available to us are not well adapted to interpreting the phenomena associated with and the probable outcomes ensuing from the national innovation system. This recommendation suggests the need for new tools to: 1) give us a better view "over the hill" and do better foresight on technology possibilities and outcomes and 2) aid us in crafting policy in a way that leaves us less vulnerable to our limited means for perception and provides for more adaptive and flexible response to emerging events and future outcomes. In this realm, there is certainly a need for exploration. But for this exploration to occur and be encouraged there must first be explicit recognition of the need. Making strides in these directions would, in themselves, be innovative activities, providing better instrumentation for observing phenomena about which we care a great deal in very much the same way that the latest large astronomical arrays, for example, permit observations of physical phenomena that our own native senses would leave unperceived.

3. Measuring Performance in R&D

Recommendation: a) Work to improve methods for measuring the long-term social and economic performance of investments in basic research.

The measurement problem is easier in industry because the research they conduct is targeted towards a practical application foreseen in advance. Much of the research conducted in the private sector is based upon findings generated by fundamental research. Yet, it is difficult to measure the direct outcomes from basic research until long after the fact. This raises a serious question: how do we determine what research priorities should be and how do we measure the achievements of the programs we put in place to meet those research priorities? Further, any

measurement method, no matter how clever, yields little benefit if not used. Recent changes in measuring government performance, such as the Government Performance and Results Act (GPRA) have resulted in a larger interest in and constituency for implementing performance measures. It is an important direction for policy in regards to the national innovation system.

4. International Dimensions

Recommendations: a) Identify centers of excellence in science and technology to encourage linkages and leverage across national boundaries;

b) Examine the global patenting system for ways to improve process efficiencies;

c) Identify ways that government can facilitate product and process standardization across national boundaries and determine when it might be appropriate to do so from the perspective of U.S. interests.

The dense web of activity and interaction that has come to characterize the national innovation system does not end at the nation's natural borders. Collaboration at the research and development stage is an increasingly important factor in the discovery, application, and diffusion of knowledge. In many areas of science, no one nation can make the investments needed to stay at the head of the pack. There are many ways to take better advantage of global science, from creating a database of information about where excellent research is taking place to providing grants to collaboration that could further U.S. innovative efforts. Beyond this, there are issues arising from intellectual property, standards, and security concerns that would benefit from early explicit attention by government.

RECOMMENDATIONS FOR NEAR-TERM ATTENTION

Given the complex and interactive nature of the national innovation system, no single policy action will serve as a sole means for enhancement. Like a finely-tuned motor, all the features of the system must work well and interact effectively. However, in the course of preparing the policy directions outlined above, the project team came to believe that they were not all necessarily of equivalent weight and immediacy. Some could be identified as actions to be undertaken at the federal level in a relatively short time that might improve the overall operation of the system. These are offered below as candidate early agenda items for careful consideration by any federal administration seeking to support innovation. These recommendations fall into three categories: 1) those reflecting a change in federal government policy and needing budgetary action; 2) those requiring legislative action; and 3) those needing near-term and effective examination and study.

Budgetary Action

- Among the recommendations listed in the previous section, perhaps the most important is **ensuring adequate levels of public funding for fundamental science and engineering (A.2.a.)**. Money should not simply be thrown at the R&D system in the expectation that useful outputs will ensue. Yet, there is every indication that the traditional valuable role

played by federally funded basic research has not diminished and might well be increasing. Recent increases in private sector recognition of opportunities for R&D investment should not be confused with the type of activity that is unlikely to be pursued except through publicly provided means. Bipartisan support in Congress for increasing federal spending on R&D has grown over the past three years, with several promising proposals before the Congress. But spending should not be targeted solely to one or two "hot" areas. Studies show that it is not possible to anticipate where exciting new developments will arise. Increased funding across a carefully constructed "portfolio" of investments will help ensure the health of the national innovation system.

Legislative Action

- In parallel to recommendations related for publicly funded R&D, a parallel item that should command early attention is to **carefully consider the benefits and implications of making permanent the R&E tax credit** (A.3.a.) This tax credit has been available on a renewed temporary basis for a number of years and has wide support among business leaders as an incentive for innovation. It could be made more effective as a permanent tax credit, thereby aiding planning for future R&D spending. There are also critics who question its necessity and efficacy. In view of increased support in Congress to enact a permanent tax credit, the issue is one that calls for careful and comprehensive early examination.

Preparatory Action

- Clearly, information flows within the national innovation system are a primary cause for its dynamism. Information engenders new opportunities for innovation and the new ideas, in turn, require protection. Intellectual property protection is an element of support to the national innovation system specifically provided for in the U.S. Constitution. How information flows, who controls and owns it, and the effectiveness of adjudication measures directly affect the health of the system. In the crucial realm of intellectual property rights and their protection, a new administration should **carefully consider the global patenting system** (D.4.b.) and the effects of varying protocols and regulations on the ability of the U.S. to promote its products in world markets. Relatedly, an improved understanding of the flow and balance of **government-funded research and the effect of technology transfer on the private sector** (B.1.b.) is crucial for a clearer policy perspective on the overall system. A general review of policies in the areas of intellectual policy formation, transfer, and protection would be in order.
- Trained workers make the economy go. The U.S. technology-based industries report that critical shortages of trained personnel are hampering the rate of innovation. Increased attention should be paid to **opportunities for training and re-training the science and technology workforce** (A.1.c.)

- Finally, although broad in concept, **raising awareness within federal agencies of their role in providing the infrastructure for the national innovation system** (C.1.a.) could play an important role in the consideration of policy, improving its formulation, and in better serving the public interest. Within this general mandate, several initiatives could be considered ranging from raising the prominence of formal awards, such as the Malcom Baldrige Award, for excellence in areas of technology development or quality assurance, to exploring means for rapidly identifying and diffusing among agencies best practices in dealing with the complex issues of national innovation system support. The rapid transformation being brought in the business and social spheres through changes in S&T should be reflected by a federal mechanism that is responsive to changing needs and requirements.